*https://doi.org/10.31925/farmacia.2021.1.20* **ORIGINAL ARTICLE**

# INCREASING ENDURANCE IN PHYSICAL EFFORT BY ADMINISTRATION OF INOSINE

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**Abstract**

The use of banned substances in order to increase the performance capacity is one of the most widespread problems in the entire sports world. This study intended to provide an alternative for sustaining intense training or a training with a high-load of competitive means. Particularly, performing martial arts require good endurance to accomplish the technical actions under the normal parameters where the body may lose energy, vitamins, and many minerals. The present qualitative study assessed the impact of a dietary supplement containing inosine, on performance in 30 athletes, with a competitive experience of about 6 - 8 years. The objective was to establish the level of endurance at different times for athletes who practice martial arts in both full contact and semi-contact systems. Thus, depending on the type of sport practiced, results recorded in the endurance tests, following the administration of inosine based supplements, showed an improvement in the athletes who practice a martial art of full contact type that requires a good endurance to perform technical actions in speed-strength regime.

**Rezumat**

Studiul de faţă reprezintă o cercetare calitativă cu privire la utilizarea suplimentelor alimentare pentru a creşte performanțele în cadrul antrenamentelor sportivilor de performanță. Cercetarea s-a realizat pe 30 de sportivi, cu o experiență competițională de aproximativ 6 - 8 ani. Utilizarea substanţelor interzise în scopul creşterii capacităţii de performanţă reprezintă una dintre cele mai răspândite probleme din întreaga lume sportivă. Scopul acestui studiu este de a oferi o variantă de susținere a antrenamentelor intense prin utilizarea inosinei ca supliment nutritiv. Aceste antrenamente cer o rezistență bună pentru a desfășura acțiunile tehnice în parametri normali, corpul consumând energie, vitamine și minerale. În studiu s-a urmărit nivelul anduranței în diferite momente pentru sportivii ce practică artele marțiale atât în sistem *full* contact cât și semi-contact. Studiul a evidenţiat că administrarea inosinei ca supliment nutritiv a crescut rezistența sportivilor care execută acțiuni tehnice *full* contact în regim de viteză-forță.

**Keywords**: inosine, dietary supplements, sports performance, endurance

## Introduction

Trainers and athletes have always looked for ways to improve their performance to achieve success in competitions [1], one of such approaches is provision of the physiological requirements [2]. The concept of "food supplement" is relatively new as it was introduced to the field of food and nutrition in the last two decades of the 20th century [3].

The legislative foundations for food supplements were laid in the United States after a constructive dispute between the Food and Drug Administration (FDA), supplement manufacturers and consumer representatives. This led to establishment of "Dietary Supplement Health and Education act of 1994" to regulate dietary supplements, by considering them as food and not medicines.

At European level, the first legislative act with reference to food supplements, was "Directive 2002/46/EC of the European Parliament and of the Council of 10 June 2002" [4].

Food supplements are intended for oral consumption (administration) by healthy people who require higher exogenous intakes due to specific nutritional requirements related to physiological status, age (children, adolescents and senior citizens), intense physical activities etc. [3].

Experts on high performance sport define it as specific sportive activities usually competitions where athletes are ranked by a number or a rating scale value [5].

Most sports involve a certain form of endurance, and the type of endurance developed (at low or high intensity) can substantially affect the performance [6]. Since ancient times, certain substances have been used to boost body's physical and mental performance [7].
The dietary regime recommended for endurance athletes involves high protein and carbohydrate consumption, but very low fat intake together with the consumption of certain key micronutrients such as iron, calcium, and essential fatty acids [8]. The right dietary supplements vary based on the body type, age and sex, as well as the athlete's lifestyle and diet [9].
The use of doping pharmacological agents is one of the major negative aspects in sports, that must be carefully monitored [10].
Aerobic endurance exercise improves cell oxidative capacity possibly *via* increasing mitochondrial oxidative enzymes levels and boosting cellular insulin sensitivity in geriatrics [11].
Endurance athletes are at particular risk for dehydration, primarily because of increased fluid loss *via* sweating as a result of prolonged and intensive periods of exercise [8].
A research done within the International Athletics Federation, from 2005 to 2007, reports that 85% of top athletes and 91% of endurance runners used supplements [12].
Scientific investigations have focused on a variety of ergogenic aids that may improve aerobic and anaerobic performances [13]. An important aspect in regulating human metabolism and energy expenditure is represented by chrono-nutrition and the temporal regulatory pattern of activity-feeding-resting relationship [16].
In the early 1980's, Russian and Eastern Bloc weight-lifters began to experiment with inosine supplementation, and as a result, many anecdotal claims about its ergogenic effect on strength, surfaced [13]. Inosine has a number of potentially important roles that may enhance training and/or exercise performance [14]. Inosine is produced in the human body, and its chemical structure is related to adenosine, which is included in adenosine triphosphate (ATP) as the energy source during the work done by each muscle; this product is popular with athletes who focus on endurance, as well as strength sports performance [15].
This supports the functioning of the cardiovascular system and through provision of oxygen and nutrients to the muscle; it increases the oxygen supply to the muscle tissue. Currently, inosine is widely touted by several companies as an effective energy booster, based on testimonials and rumours, has been used by Russian and Eastern Bloc athletes [17]. The principles of quality nutrition and the use of special nutritional supplements are valid for all sports, but the type of effort made must be taken into account. Consequently, prolonged inosine supplementation does not appear to improve aerobic performance and short-term power production during cycling and may actually have an ergolytic effect under some conditions [13, 18].
Dragan *et al*. [19] showed that 6-week inosine supplementation improves motoric speed conductibility of the popliteus nerve of Olympic weightlifters, but they reported no performance data. Although marketing claims [20] suggest that inosine benefits athletes involved in anaerobic as well as aerobic events, little if any empirical data exists to support these claims.
Excessive use and/or prolonged misuse has no ergogenic effects, but may cause possible health problems if taken over long periods of time; uric acid concentration was shown to increase significantly after days 6 and 11 [21].
Herbal dietary supplements are taken by physically active individuals for a variety of reasons, including increasing energy, losing weight, promoting muscle growth, or inducing other physiological or metabolic responses that may enhance exercise performance [22]. However, sports nutrition products are not an appropriate substitute for a varied and balanced diet which is best suited for children and adolescents.
In this study, the impact of inosine as a dietary supplement on performance in athletes practicing martial arts, was assessed.

## Materials and Methods

*Study design*
A total of 30 athletes of both sexes practicing martial arts, who volunteered to participate, were enrolled in this study. At the time of testing, all athletes had a break of competitive training for at least two months.
All procedures related to this study were performed in the gym of the Physical Education and Sports Department within the University of Medicine and Pharmacy "Carol Davila", Bucharest, Romania. The participants completed a questionnaire on medical history and signed a written consent for testing. The present study was conducted in one week.
*Study protocol*
The test protocol consisted of the following three endurance-focused tests:
Test 1: motor reaction to visual stimulus (maximum number of different motor actions executed at the same speed and intensity), measured by Kinovea video analysis program; test 2: simulated combat based on specific time frame, depending on the sport (different technical actions executed, depending on the specific regulation, on mobile targets on both attack and counter attack), measured by Kinovea video analysis program; test 3: force exerted on the mean circular action performed with a lower member, upon choice (this test was not performed for the practitioners of wkf karate, being a semi-contact sport) – measured by an electronic jacket, Daedo, Gen 1 PSS Electronic System, placed on the dummy, with Gen 2 E-Foot Gear Protector for athletes, and connected to a computer

with standard ring management software for use with True score wireless systems Daedo Gen1 Software upgrade, which can be adapted according to the weight category.

All athletes were initially evaluated following a three-day break. On the fourth day, they got two capsules of inosine (500 mg of inosine *per* capsule) in one administration, approximately 30 minutes before the exercise, followed by 15 minutes warm up and the final evaluation. The dose of the administered dietary supplement with one gram inosine has the following characteristics: energy value 3.4 kJ/0.8 kcal, 0.2 g of proteins [16].

Competitive efforts were made during the training, only after analysing the competitions types and their number. These kinds of effort are very important at the end of the preparatory and competitive phase, largely determining the rate of sports performance enhancement.

The measurements and evaluations were done using the following tools: Pulse Oximeter, Polar A 370 and Kinovea video analysis program. Statistical analysis was performed using SPSS, version 23.

Figure 1 provides an overview of the three tests performed in our study.

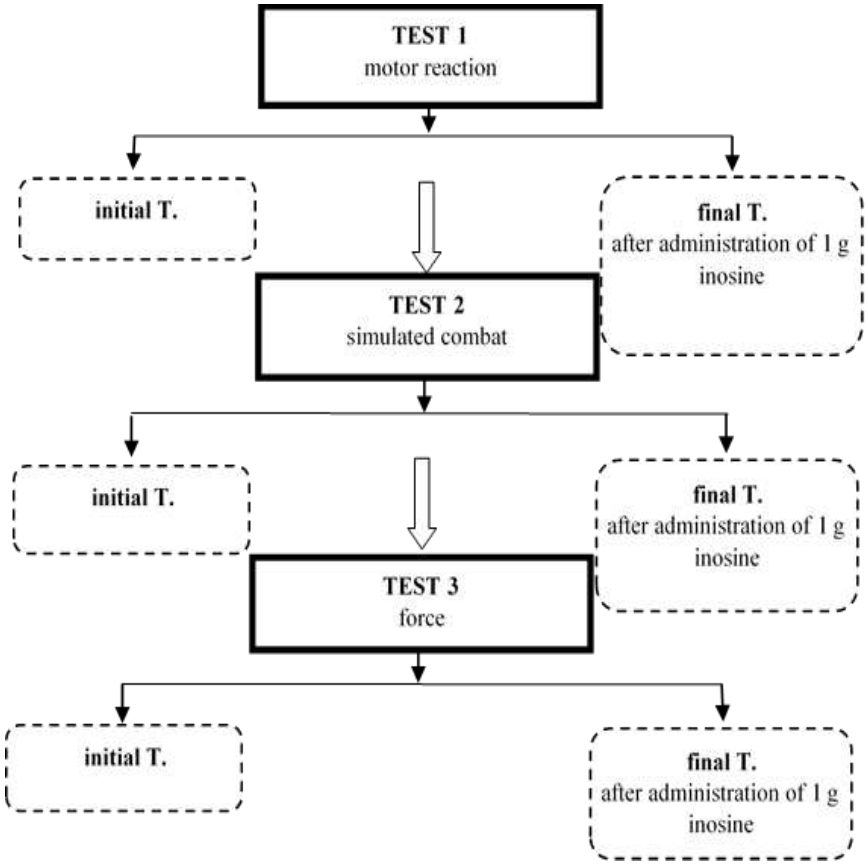


**Figure 1.**
Viscosity curves and the statistical mean of differences expressed by the regression lines

## Results and Discussion

Our results revealed that administration of 1 g inosine, according to the sport practiced, produced some significant differences.

A total of 30 athletes of both sexes (age (mean ± SD) 23.3 ± 1.9 years; height (mean ± SD) 170.6 ± 9.1 cm; and body weight (mean ± SD) 65 ± 12.2 kg (Figure 2)) practicing martial arts, who volunteered to participate, were enrolled in this study; all participants had a competitive experience of about 6 - 8 years, 10 practiced taekwondo wt, 10 karate wkf and 10 ashihara karate.

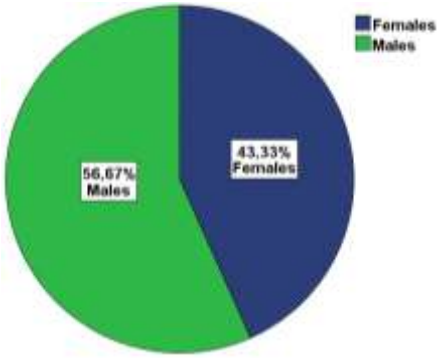


**Figure 2.**
Study population

Based on the Pulse Oximeter test results, at the final test, the peripheral oxygen saturation (SpO2) was higher by 2%, after mixed/anaerobic effort and by only 1% after aerobic type. As shown in Figure 3, the time spent in the exercise zone increased after inosine administration. The analysis of the data showed that this increase was significant, on mean by 18 seconds, for the specific competitive effort.

As can be seen in Figure 4, after administration of 1 g inosine, the time spent in the exercise area increased and the average heart rate increased from 146 to 162 beats/min, so athletes could sustain greater effort.

At the final test, after administration of inosine, an increase of 14 - 15% in the number of technical actions for the test of motor reaction to the visual stimulus (Test 1), was observed (Figure 5).

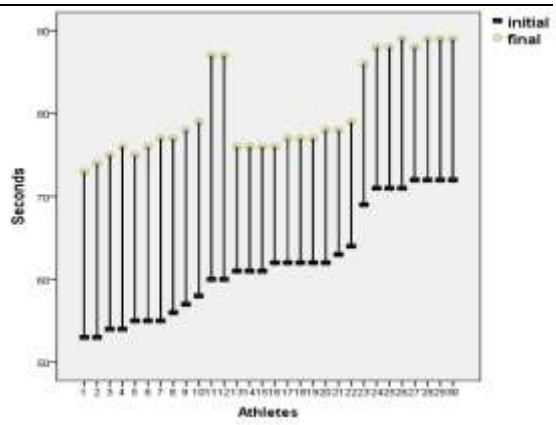


**Figure 3.**
Time spent in the area of specific competitive effort

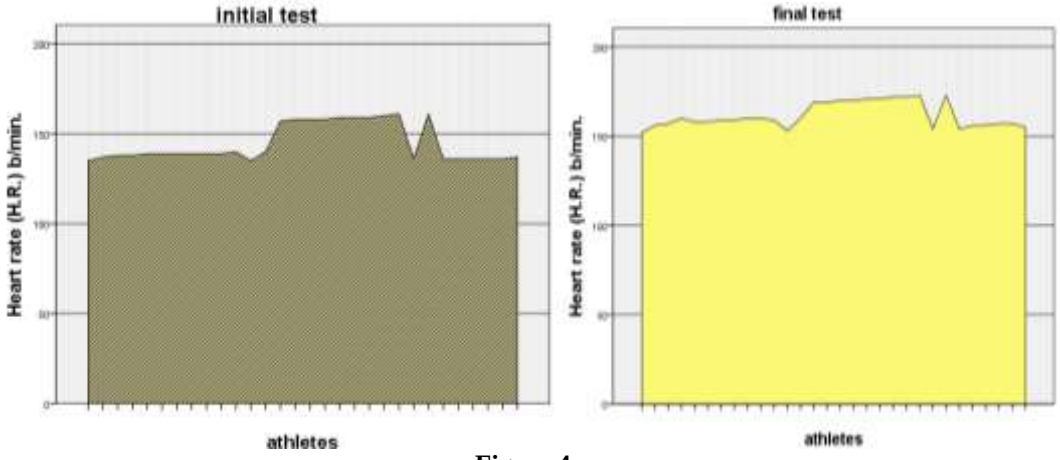


**Figure 4.**
The evolution of the average heart rate in specific competitive effort Test 2

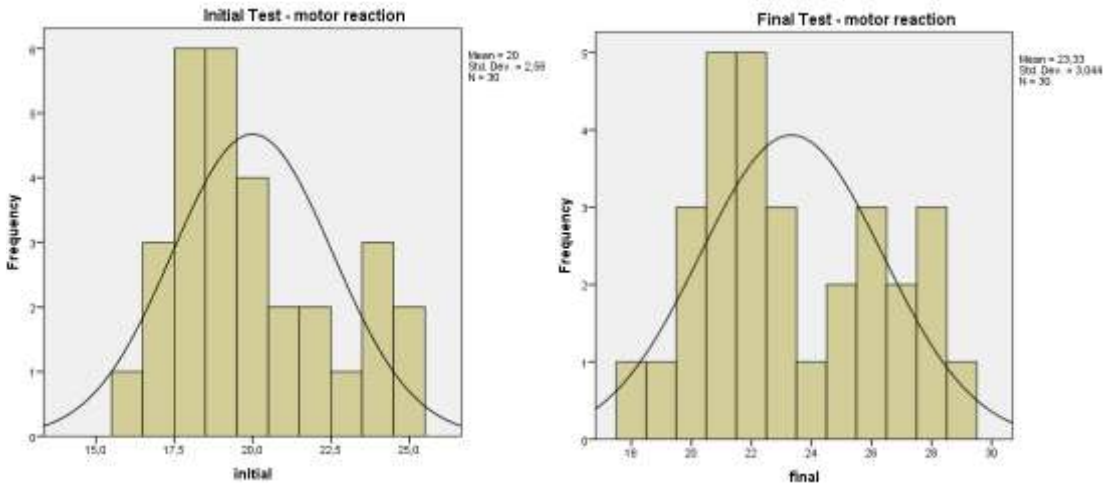


**Figure 5.**
The number of technical actions performed on the motor reaction -Test 1

The mean number of technical actions (Figure 6) increased from 72.67 ± 46.73 in the initial test to 97.67 ± 66.26 after administration of inosine, showing a bidirectional level of significance ($p < 0.01$). The correlation between initial and final tests was statistically significant.

On average, the participants' results improved by 23.66%, compared to the initial testing.

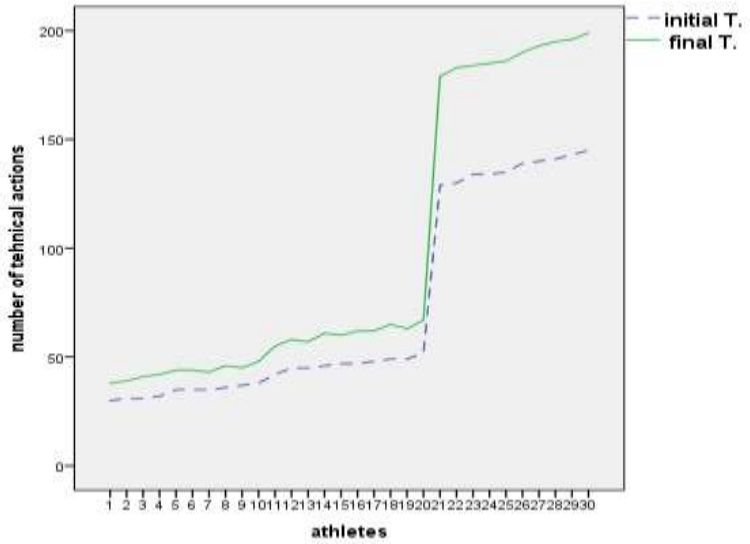


**Figure 6.**
The number of technical actions performed during specific competitive effort (Test 2)

In the strength test, only the athletes from the two full contact sports were investigated. Thus, after the administration of inosine, there were increases of 24% for taekwondo and 22% for ashihara in the number of executions (Figure 7).

There is data supporting the fact that athletes use a variety of dietary supplements from both natural and organic sources, to increase energy levels, maintain endurance, health and immune system functioning, improve performance and prevent nutritional deficiencies that compromise health [23].

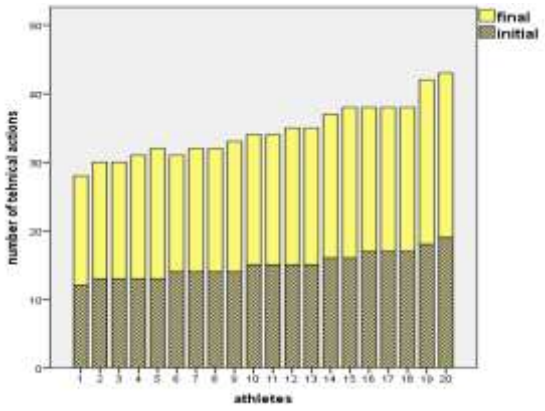


**Figure 7.**
The number of technical actions performed at medium level with constant force (Test 3)

As an endogenous purine nucleoside, inosine produced following formed adenosine breakdown adenosine deaminase, is released into the extracellular space during metabolic stress or from the sympathetic nervous system [24, 25]. *In vivo* and *in vitro*, it was shown that inosine suppresses the production of pro-inflammatory cytokine and chemokine production but induces the production of the anti-inflammatory IL-10 [26].

Besides, inosine degradation produces urate which is a valuable endogenous antioxidant and an oxyradicals and peroxynitrite scavenger [27-29]. It was observed that uric acid supplementation *in vivo* has protective effects against shock [29] and neuroinflammation [30].

Data obtained in the present work showed an increase of 1 - 2% in SpO2 depending on the type of effort (mixed, anaerobic or aerobic) after the administration of 1 g inosine.

In the case of the time spent in the effort area according to tests 1 and 2, substantial increases of 8 (test 1) and 22% (test 2), respectively were observed, in terms of endurance, which also led to an increase in heart rate (HR).

Thus, the effort size was obtained by comparing the mean value of HR to the maximum values calculated according to the well-known Astrand formula "HR Mx = 220 - age".

For taekwondo wt practitioners, the effort grew from intense with an HR mean of 159 b/min at maximum effort to 171 b/min. For wkf karate athletes, the effort increased from optimal with an HR mean of 155 b/min to intense with an HR mean of 163 b/min. For the ashihara karate practitioners, the effort increased from optimal with an HR mean of 139 b/min to intense with an HR mean of 159 b/min.

It is known that in taekwondo where the technical actions are executed in speed-strength regime, good endurance is required, and because multiple technical actions are performed, the scoring is made electronically, automatically without too much intervention from the referee.

Thus, the number of technical actions performed during a match, significantly increased for all three branches of sport namely, taekwondo wt 27%, karate wkf 21% and ashihara 23%. Thus, our intervention led to a

larger enhancement for taekwondo where endurance is needed.

Williams *et al*. in a crossover study, assessed ergogenic properties of inosine (6,000 mg/day for 2 d, orally) in terms of 3-mile run time and VO2 peak, in 9 endurance runners; results showed that inosine supplementation had no effects on the above-mentioned factors, suggesting ineffectiveness of inosine for aerobic sports [20].

Nevertheless, having in mind safety profile of inosine in humans, its anti-inflammatory properties observed in human cells [31] and *in vivo* [32-35], further testing of inosine in humans is suggested.

## Conclusions

Administration of 1 gram of inosine, had a significant increasing effect of 24% on the competitive motor performances. In our study, according to the sport practiced, the best results were achieved for the athletes who practice a martial art of full contact type that requires a good endurance to perform technical actions in speed-force regime. Nonetheless, the least influence was observed for the motor reaction if it is not causally related to endurance. Thus, we can argue that for the athletes enrolled in the study, as a result of supplementing the effort capacity with inosine, there was an increase in the endurance and performance according to the type of competition effort.

## Conflict of interest

The authors declare no conflict of interest.

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